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ABSTRACT

This critical, analytical, and interpretive review of three National Science Foundation-supported studies of the state of precollege science education examines the implications that these studies may have for the science community. Areas discussed include student problems, teacher preservice and inservice education, curricular innovations and reforms in elementary and secondary school science, laboratory instruction, teaching resources, national and local perceptions of the educational system, and values problems. One recommendation made among others is that a commission be established to examine in depth the goals and purposes of precollege education. (Author/CS)

A REPORT ON THE IMPLICATIONS FOR THE SCIENCE COMMUNITY OF THREE NSF-SUPPORTED STUDIES OF THE STATE OF PRECOLLEGE SCIENCE EDUCATION

Report prepared for the
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ABSTRACT

The three NSF-supported studies of the current status of precollege science, social studies, and mathematics education give substantial evidence that serious attention needs to be paid to improving the quality of that education.

Improving quality is not just a matter of developing up-to-date curricula. That was done in the 1960s by various groups with generous financial support from the NSF. But the data in the three reports indicate that the new curricula have not been spectacularly effective. They are viewed by teachers and students as "elitist," and in a sense they are. They were produced at a time when national concern was on producing more scientists--in competition with the Soviet Union--more than on educating all students to understand the natural and social sciences and mathematics.

But the problem of improving science, social studies, and mathematics education is broader than curriculum. Together with all parts of the elementary and secondary school curriculum, education in science is influenced by the school ethos. Lack of respect by students for authority; hesitancy, for various reasons, including legal, of teachers and administrators to impose discipline; assignment of teachers to subjects for which they are not properly prepared; lack of motivation of students; financial constraints; and many other factors are having a negative effect not only on science education but on education in general.

The findings of these studies lead us to conclude that the time is ripe for an examination in depth of the goals and purposes of precollege education. We recommend that a commission--similar to the 1893 "Committee of Ten"--of the highest quality and with nationally recognized and respected leadership be established to carry out the examination.

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Introduction

This critical, analytical, and interpretative review of three NSF-supported studies of the state of precollege science education was prepared by Herbert A. Smith, Assistant to the Academic Vice President, Colorado State University, with advice from a panel of educators.* The report examines the implications the studies may have for the science community and recommends lines of action.

Although the three studies were designed to accomplish the same general purposes, they approached the task in quite different ways.[1-7] The Research Triangle Institute study is a report of a questionnaire investigation which collected a massive amount of data from a large number of respondents. The Illinois report is based on a series of case studies involving school systems in eleven different communities. The Ohio State study is an exhaustive review of the available literature on science, social studies, and mathematics education (1760 individual citations).

Large amounts of data were collected and the reports of the three studies are voluminous. While survey studies provide useful basic data, they, by necessity, report on what is rather than on what ought to be. The reports are a pioneering effort providing an impetus for many other kinds of studies. Subsequent research efforts can explore implications, carry out experimental research or in other ways follow up in more detailed and reflective modes on the data made available through survey efforts.

In reviewing the studies, we did not find a certain kind of data that would be helpful in considering the state of science education. The sort of data we refer to is much in demand in service fields, such as agencies that give aid to families or clinics that serve individuals. Usually the data are more readily available in the form of total number of services of a given kind, but not in the more valuable form that allows us to appreciate the distribution of the services to individuals or to families. Consequently it may be easy to tell how much of which service is being used, but not how the services are distributed among the clientele. This latter may be information needed if a vigorous attack were to be mounted on the basic problem. Some individuals may use the service heavily and others not at all, possibly giving a misleading idea of the widespread use of the service.

In the field of education, although we know something about how many courses are given or how many students take a given course in the studies being reviewed, we do not have much information about how many courses in science a student takes. Thus we do not know much about the distribution of science

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[1-7]For citations see page 2.

education across students. In a similar vein we do not know how much science the teachers of science have studied, or what kind. We do not know the distribution of science preparation across the teachers.

It is possible, of course, that these sorts of information are available in other publications, but they did not seem to be present in the studies we reviewed. This is a form of data that would help us interpret current states of education in the sciences.

Because of the open-ended nature of case study reports, the Illinois report is perhaps the most interesting. Nevertheless, there are a number of limitations which seemed apparent to the reviewing panel. There is great variation in the quality of the reports submitted by the field research workers. Some of the observations reported have almost a mirror-like quality that provides the basic documentation for the kinds of perceptions that the observer found worthy to report. At the other extreme, one occasionally finds an

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[1]Case Studies in Science Education: The Case Reports. Center for Instructional Research and Curriculum Evaluation and Committee on Culture and Cognition. University of Illinois at Urbana-Champaign, Volume I, January 1978.

[2]Case Studies in Science Education: Design, Overview and General Findings. Center for Instructional Research and Curriculum Evaluation and Committee on Culture and Cognition. University of Illinois at Urbana-Champaign, Volume II, January 1978.

[3]The Status of Pre-College Science, Mathematics, and Social Studies Educational Practices in U.S. Schools: An Overview and Summaries of Three Studies. National Science Foundation Directorate for Science Education, U.S. Government Printing Office, July 1978.

[4]Stanley L. Helgeson, Patricia E. Blosser, and Robert W. Howe. The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975. Volume I: Science Education. Center for Science and Mathematics Education, The Ohio State University, Columbus, Ohio, 1977.

[5]Marilyn N. Suydam and Alan Osborne. The Status of Pre-College Science, Mathematics and Social Science Education: 1955-1975. Volume II: Mathematics Education. Center for Science and Mathematics Education, The Ohio State University, Columbus, Ohio, 1977.

[6]Iris R. Weiss. Report of the 1977 National Survey of Science, Mathematics and Social Studies Education. Center for Educational Research and Evaluation, Research Triangle Institute, Research Triangle Park, North Carolina, 1978.

[7]Karen B. Wiley and Jeanne Race. The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975. Volume III: Social Science Education. Social Science Education Consortium, Inc., Boulder, Colorado, 1977.

instance where a field worker used the opportunity for his own intellectual tour-de-force by digressing into theoretical, philosophical, or speculative side trips without giving the reader sufficient background of specific observations or instances which would lend substance to the arguments. It is perhaps appropriate to mention that, of the several field workers, only one had what might be called a reasonably "typical" background in either natural science or mathematics education. The field workers tended to be highly qualified individuals with evaluation backgrounds. Some had background in the social sciences. No doubt science and/or mathematics educators would have been inclined to report different incidents and perhaps make more valid judgments as to the substantive content of the lessons and laboratory exercises that they might have observed. It is obvious and perhaps inevitable that the different field observers placed their own individualistic stamp in reporting their observations, which also inevitably are colored by their own value orientation and biases.

It is the purpose of the present report to make a beginning at effective follow-up through a reflective commentary on issues raised and to suggest some of the broad implications that the three reports might have for the scientific community.

The present report has its own limitations and falls short of mining all of the potential implications from the data made available. Because of the scope and extent of the three studies, it was necessary to be selective. The selection process is bound to reflect values and biases of the reviewing panel and of the writer of the report, and will certainly reflect their judgments as to what is relatively most important. The panel also recognizes that it is impossible to provide more than a preliminary analysis of many of the issues and problems identified that would be individually worthy of a full-scale monograph in their own right. Still, the panel hopes that it has provided a valuable service in its efforts to prepare a succinct report which will be useful to the scientific community in stimulating critical thought and in making the reports more useful in the improvement of science education.

There is no doubt that these reports will provide a data base and a starting point for a variety of studies for many years into the future. There are some inconsistencies among the findings which will serve as an incentive for further investigation. It was conceived to be the function of this review panel to examine the reports in an effort to identify the major issues that appeared to emerge from the studies and to explore what some of the implications of the findings might be. Because it could not do everything, the panel has elected to look primarily at areas of concern that relate to (1) the social setting of education, (2) students, (3) teachers, (4) curriculum, (5) laboratories, and (6) teaching resources. It is obvious that these are not mutually exclusive domains and that to treat them as such is primarily a convenience. There are essential interactions among all of the areas.

Some General Considerations

Before the beginning of a discussion of the specific areas identified above, it seems both appropriate and necessary to provide some commentary about some general problems that seem broadly related not only to these three studies, but

to education in general. The studies underscore some of these difficulties. Some explicit examples will make evident why data reported in these studies (and others) need to be used and interpreted with caution. One problem is the use of terms--for example, "science." The three studies are inconsistent among themselves in use of the term "science." At various times it means the natural sciences, or the natural sciences and mathematics, or the natural sciences, mathematics, and social sciences. In general usage, such terms as inquiry, laboratory, grouping, tracking and inservice education are used to describe a wide array of qualitatively very different activities. For example, the term "inservice education" covers a spectrum of activities ranging all the way from an after-school pep talk by the school principal, to committee work, to travel, to nonrelevant off-campus classes which happen to be offered nearby, to carefully designed local inservice workshops for teachers, to college coursework (any kind), to highly relevant graduate or undergraduate studies or other activities. Thus, when teachers respond to questions about the value of inservice activity it is difficult to determine precisely what it is that they are responding to. Similar statements could be made for other terms used throughout the studies.

A closely related issue is that of "quality." A frequency count to determine how widespread a particular phenomenon may be is unhappily no index of its quality. The issue of quality is present in virtually every aspect of education. It is a concern in such diverse areas as teacher-student interactions; the manner of use of laboratory activities and textbooks, or any other instructional material; tests and evaluation; inservice education; administrative procedures; and organizational structure of the school system. The vital question is not only "what," but "how good." The reports of the case study workers (CSSE) sometimes permit inferences to be made of the quality of the activities that they were observing. The Ohio State report on science education called attention to this problem by pointing out that there are substantial data regarding the implementation and use of materials but that there are relatively few data on quality of use.[8]

Another area of great concern to education is the weakness of its research base. As these studies point out in several instances, there seems to be a lack of general direction, a lack of sufficient background of educational theory that would give direction to and provide the basis for the development of dependable research findings. It is obvious, particularly from the report of the Center for Science and Mathematics Education, that a large proportion of educational research is noncumulative and is often inconclusive or even contradictory.[9] Some of this may be attributable to faulty design, inadequate research conceptualization, or some other factors. However, it seems probable that there are other more general factors involved. Certainly problems of definition and the absence of a substantial theory base are a major part of the problem and contribute largely to the fragmentation and ineffectiveness of much research effort. It might also be conjectured that at least some of the problem is due to the extreme complexities involved in educational problems. For example, in studies of student learning, it might be argued that the impact of any single variable

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[8]Helgeson et al, op. cit., p. 16.
[9]Wiley and Race, op. cit., pp. 154-58.

is likely to be very small considering the total universe of variables which affect each student so that significant observable change as a result of the manipulation of a single variable is unlikely. Herein may lie some of the reasons for much inconclusive educational research. It may imply the need for far more sophisticated and comprehensive research designs and far greater precision in identifying, limiting, defining, and measuring research variables.

It should also be recognized that there are large areas that the three reports either do not touch at all or that are touched only tangentially. For example, very little material is presented about individual students. There are repeated references to the lack of motivation, boredom, poor discipline and laziness, but not much information or insight is gained about how the student came to be bored, unmotivated, lazy or a discipline problem. Little can be learned about individual student aspirations and goals, although some reporting on individual students does appear in the CSSE reports. The student tends to appear as a "collective" rather than as an "individual." Practically nothing is included on student-teacher interactions other than in the formalized recitation-discussion classroom setting. The impacts of the world outside the school--the home, the community and its organizations, its distractions, including TV--are touched upon in a generalized manner, but usually not with reference to their influences on individual students. There are no data, except for a hint or two here or there, about the impact of peer pressure on teachers indicating how they are expected to conform. Very little information is provided about how teachers use their time or how efficient such usages are. The large hiatus with respect to "quality" has already been alluded to. Other examples could be given but these should be sufficient to indicate that, as large and as comprehensive as the reports reviewed are, they leave untouched many questions and concerns which relate to education in the sciences and to education in general. As we have already said, the studies are a pioneering effort that should provide the impetus for many future studies.

The Social Setting for Education

From an analysis of the three reports, one cannot arrive at a very optimistic assessment of the state of elementary and secondary schools in this country. There are serious problems which range in diversity from apathetic, unmotivated and drifting students, deteriorating teacher-administrator-community relationships, major economic crises, poor quality instruction, inadequate equipment and supplies, federal and state regulation and determination of local policies, to widespread community dissatisfactions. Furthermore, there do not seem to be any easy or readily attainable solutions available for many of these problems. The general somber conditions impinging on education today are convincingly reflected in the three reports.

Historically, there has always been a high correlation between the level of education and income as well as in the quality and satifactions of life which an education tended to ensure. In recent decades, many of these benefits have tended to disappear. Students were quick to point out to field observers that teachers, in spite of all their erudition, were often far less well off financially than either their less well educated parents or other craftsmen in the community.[10] Thus, students are questioning the economic values of an education.

[10] Case Studies in Science Education, Volume I, op. cit., Chapter 4, p. 43.

One might look elsewhere for some of the reasons for this view. Undoubtedly the general increases in the standard of living, a narrowing of the income differences between "blue collar" and "white collar" occupations, economic policies, such as the progressive income tax, and the inheritance tax, broad-scale welfare programs, uniform salary and wage scales and a permissive social climate have all contributed to a lessening of incentives conducive to outstanding performance. One of the field reporters reported teachers' comments as follows:

> We have lost our work ethic. School is for entertainment. Parents, teachers, and children have lost appreciation for education. They want to be rewarded for performing any kind of work. Rewarding effort no matter what the quality of the product is a part of it.[11]

This brief quote raises questions about attitudes toward work, the purposes of school, "success" without effort and the general question of quality. It is a succinct statement reflecting on the malaise affecting both schools and society.

It is impossible to consider the role of the schools as social institutions without thinking seriously about the many outside forces that influence and direct the activities of the school system. One study reported that "schools were the creatures of the social system more than of the Academy."[12] Implicit in this statement is recognition that the public schools are a creation of government and that they are exposed and highly sensitive to the political process. Up until about 25 years ago the political sensitivity extended mainly to the local community with some concern for the state level. However, all of this has changed in the last 25 years and now the federal government and expanded state educational bureaucracies assume much larger roles with respect to the operation of schools.

One observer pointed out that the curriculum is definitely a low priority consideration when attention is focused on such matters as minimum competencies in reading and mathematics, desegregation, accountability, and public relations in the community.[13] Clearly, the attention of administrative leadership in school systems today is not focused on curriculum and program development. One observer made the following assessment and provides a rather revealing vignette of the disaster of external intervention:

> The personnel in the school are under duress. The organization they work in has been severely affected by budget cuts; loss of student population; materials distribution problems; court decisions that enforced the equalization of teaching resources, but introduced guidelines contradictory to those of federally-funded programs; court decisions that forced mainstreaming of all kinds of students; the

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[11] Case Studies in Science Education, Volume I, op. cit., Chapter 1, p. 59.

[12] Case Studies in Science Education, Volume II, op. cit., Chapter 16, p. 26.7.

[13] Case Studies in Science Education, Volume I, op. cit., Chapter 5, p. 9.

general poverty and high unemployment rate of the parental constituency of the public schools; the high crime rate, particularly vandalism and theft, that is often counterpart in urban settings of these economic conditions; and by a system heavily dependent on federally-funded special programs characterized by short-term abundance followed by reduction, squeeze-out and pull-out for national, rather than local reasons.[14]

Whatever may be the merits on philosophical or political grounds of the broad-scale judicial intervention that has occurred in the last two decades, it has created a problem for local public schools. Court ordered mainstreaming of children with serious behavioral problems has eroded the teacher's authority and reduced ability to maintain classroom control. It is regarded as such a serious imposition that in one case the teachers banded together to petition the union to initiate a class action suit on their behalf to obtain relief. One parent was quoted as saying that "juvenile delinquents are placed in the schools by the courts regardless of their effect on other children."[15] In another school that was under a court order involving desegregation practices, the observer felt constrained to comment that "the school feels it has been left to cope with situations not of its own making, that decisions have frequently been taken on political grounds without reference to what happens in schools."[16] One teacher seemed to speak for many and vented her frustrations in a letter to the local newspaper. She stated:

> Sometimes, I do think that courts and high officials are trying to destroy education. They certainly put enough stumbling blocks in the path. The officials and legislators here in Illinois are very quick to take a hand in making rules for and demands on schools. These have to be complied with, whether they are educationally sound or not.[17]

Governmental intervention and the pressure to make the public education system an instrument of social reform have had profound effects on the educational establishment. However successful the various reforms have been in achieving social objectives, the impact of government intervention on the quality of the educational program has been deleterious. Public schools have been substantially misshaped by the social reform efforts.

Considering the impact of government intervention in the schools, it is easier to understand why attention to instructional programs is as inadequate as it is. Real questions appear to be: How can healthy learning atmospheres be created or restored and maintained? How can instructional materials be provided that will stimulate needed intellectual growth in all students and at the same time serve the needs of society?

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[14] Case Studies in Science Education, Volume I, op. cit., Chapter 9, p. 1.
[15] Ibid., p. 17.
[16] Ibid., Chapter 11, p. 4.
[17] Case Studies in Science Education, Volume II, op. cit., Chapter 16, p. 16:26.2.

The educational system is presumably designed for the initial benefit of students, although society expects to reap ultimately a rich return on its investment in the individual. It is appropriate, therefore, that a major section of the report should treat selected aspects related to students.

Students

The three reports provide many details relating to the students and their relationships to the educational establishment. In a careful review of the materials there are a number of recurring themes and problems which seem to emerge and which merit attention in this review.

Motivation

One of the most persistent themes reflected throughout the reports of the field observers is that average and below average students are not motivated by their school programs. Even those upper ability students who are generally reported to be receiving good grades and to be doing reasonably good work are apparently motivated by the desire for good grades rather than to achieve intellectual goals.[18] There is also evidence of an "avoidance syndrome" of rigorous courses by grade-point conscious students, sometimes encouraged or advised by counselors.[19] School, too often, is seen by students as a necessary evil--a sort of waiting period before they can get on to the really important things in life like going to college or getting a job. There is little evidence that getting an education is regarded as a privilege, as an opportunity for personal development and enrichment, to be cherished in its own right. Although schools have not historically been known as beloved institutions by generations of students, it seems that the present generation of students reflects a deeper and fundamentally more serious negativism toward schools, teachers, and education in general. The indicators of such negativism are numerous and, in addition to lack of motivation, include the continuing references in the reports to boring classes, vandalism, disruptive school behavior, and pervasive anti-intellectual attitudes.

As indicated earlier in this report, while the conditions stated above are well documented in the studies, there is very little that relates to their etiology. What are the conditions--educational, social, psychological, economic--that develop these unsatisfactory attitudes in many children and adolescents? How have homes, schools, and society in general failed such children to such an extent that they become dropouts from learning and problems both to themselves and to the larger social order? What changes have occurred in the social system which account for such shifts in student attitudes and behavior? Even students who do well in their work often appear to be working for external reasons. They are concerned about grades and passing tests. The question "Will it count?" is all too familiar to teachers.

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[18] Case Studies in Science Education, Volume I, op. cit., Chapter 1, p. 89.

[19] Case Studies in Science Education, Volume II, op. cit., Chapter 12, p. 18; 25a.

It is hard to escape the conviction that many, perhaps most, students do not really have a commitment to education nor do they feel any internal, intrinsic need for self-fulfillment through educational accomplishment. The social turmoil of the sixties which was an outgrowth of the Vietnam conflict had a very profound effect on the young which still persists. Student activism successfully challenged established authority and standards in a wide range of actions.

The question of how to motivate students will continue to be one of the most perplexing problems in education and one which appears to be in obvious need of further research and analysis as well as action programs designed to recapture and redirect student motivations.

Achievement

Although assessment of student achievement was not a major focus of the studies, concern over poor achievement is reflected repeatedly by references to unmotivated and apathetic students. A quotation that catches the spirit of this concern states:

> . . . in every site teachers, administrators and parents were saying that the children have changed. In many respects they do not like the change, . . . Each generation clearly sees that the younger folks do not work as hard as they did. And now children are seen to lack motivation, concern about the future, and respect for authority. "They think too much about cars. They go off around the world. They don't settle down to a real job." Teachers are as dismayed by this view as other adults are.[20]

There is substantial evidence in these reports as well as from other organizations, particularly the National Assessment of Educational Progress and the College Entrance Examination Board, to support the position that standards of achievement have been falling steadily over the past decade or so. This includes students at all levels, including the college bound. Although there have been many attempts to explain away this finding, the evidence appears to be convincing that the decline is real. The complaints of teachers relating to student performance are numerous and among others include the allegation that things must be taught over and over again. There also seems to be evidence that learning fails to transfer efficiently. Obviously these are not new problems, but they seem to be present in a more pernicious form than formerly. One would be inclined to ask whether or not teaching is less efficient than it used to be, whether there are new conditions or influences that adversely affect learning or whether students on the average are less capable than former generations of students.

Students appear to take a very short-range view of the value of education. Perceptions seem to be that knowledge should have immediate application or should clearly relate to job opportunities. Such a view tends to fly directly in the face of intuitive knowledge that what seems highly relevant to one who is 12,

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[20] Case Studies in Science Education, Volume II, op. cit., Chapter 17, p. 25.

16, or 18 years of age is likely to have been proven invalid by the time one has reached middle life. In spite of this, courses that do not provide education that is easily identified with specific job preparation including science, mathematics, and social sciences are called upon to justify their continued existence in the curriculum. In brief, education seems caught up in the issues of general education versus vocational education, short-range versus long-range goals, and economic versus humanistic considerations.

It seems both unfortunate and incorrect that sciences are perceived to be relevant only for those who are to become top flight professionals. It is not perceived to be significant in the daily lives of average citizens. A comment by a student clearly reflects this ubiquitous view,

> When you do get into higher math and science stuff, sometimes you feel unless you're really going to continue and be a physicist or something, there's no reason to take it because you're never going to use it. Unless you're really planning on climbing the ladder and be way up there. It's practical to stop.[21]

Additional comments on the general educational functions of science are included in the section on curriculum.

Learning

Although the areas of curriculum and teaching will be considered in later sections, it is useful at this point to point out some of the interactions that students have with both curriculum and teachers. The evidence from these studies indicates that the NSF curriculum reform movements of the 1960s and particularly those in mathematics were not very successful. The several projects are perceived to be elitist in character. One field observer commented:

> It is perhaps important to note that where the curriculum reforms of the sixties found their main audience, and made their greatest impact, was on high status, high income, middle class school systems (witness PSSC, Chem Study . . .). These were, after all innovations that belonged primarily to elite groups: to the universities, the foundations, a few exceptional schools.[22]

The reform efforts tended to emphasize the structure of the discipline, in-depth learning, and laboratory activities requiring considerable thought and insight. To students who are now looking for "relevance," fulfillment of immediate objectives, job-related learnings, and practical applications of science to technology, the new curricula have little appeal. When these rigorous curricula are placed in the prevailing school and community context and when all the handicaps related to facilities, teachers not prepared to use the curricula, disciplinary problems, and the governmental requirements discussed earlier, it is not hard to understand why they are having limited success.

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[21] Ibid., Chapter 12, p: 23.

[22] Case Studies in Science Education, Volume I, op. cit., Chapter 11, p. 27.

The hypothesis that any subject can be taught effectively in some intellectually honest form to any child at any stage of development provided the psychological support and rationale for curriculum reformers to introduce more abstract and difficult materials at lower grade levels.[23] It is difficult to establish a firm connection between such a psychological concept and some of the content in the new curricula, but it seems reasonable to speculate that this view contributed to the limited success of some of the new programs. Teachers interviewed in the case study reports had very different notions about what might be appropriate for children.[24] One teacher commented:

> Earlier and earlier we expect more and more. Where will it end? We pay for it earlier and earlier, too. Scandinavians do not start their children until age eight. Their literacy rate is better than ours. In two years their children are caught up with their European counterparts.[25]

The dichotomy between students' expectations and the goals of the curriculum reformers has already been pointed out. However, it seems possible that some of the present student disenchantment, their lack of motivation, their boredom, and their lack of effort may be related to the fact that the curriculum content is not really suited to their levels and that it is indeed too difficult and too abstract for most of the students. This may imply, too, that learning theories derived from carefully controlled and ordered laboratories do not necessarily have relevance in the kinds of social settings prevailing in most schools where discipline concerns, peer pressures, and many distractions all operate to undermine the effectiveness of the learning process.

In another comment related to student learning, CSSE reported that much of the instruction observed could be characterized as molecular rather than holistic.[26] This is a key observation and is probably related to a number of problems including the misuse of teaching materials, lack of transfer of learning, and dull and unstimulating instruction. "Big ideas" are more likely to be retained by students than isolated facts. However, many of the examples of instruction that were reported in the CSSE study seemed to be emphasizing factual information without placing it in the context of larger conceptual schemes. When learning is not placed in such an overall structure and when it is not personalized or related meaningfully to the experiential background of students, it is unlikely that it will be long remembered.

Discipline

Discipline in the public schools has become a serious problem. It is referred to frequently by the field observers. One individual reported:

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[23]Jerome S. Bruner, The Process of Education, Cambridge, Mass., Harvard University Press, 1961, p. 33.

[24]Case Studies in Science Education, Volume I, op. cit., Chapter 4, pp. 24-25.

[25]Case Studies in Science Education, Volume I, op. cit., Chapter 1, p. 40.

[26]Case Studies in Science Education, Volume II, op. cit., Chapter 13, p. 44.

> The major obstacle [to sound instruction], it often appeared, what [sic] works against these efforts to be efficient and effective, was the student. Not just his poor background, but his lack of commitment to learning, his distractability, his defiance of authority, --hers too, of course. And these obstructions are not neatly contained so as to obstruct only the learning opportunity for that learner, but spill over to impede the whole class. The teacher looks for ways of intimidating or cajoling, often without success. The teacher seeks to isolate or expel the misbehaving student, often without success.[27]

The historic conception of the schools as being "in loco parentis" has disappeared. The general ambience of a permissive society has made the problem of control of students extremely difficult. Discipline in some schools has become such an acute problem that it seriously interferes with the academic program. It is a source of teacher frustration and tension and may be part of the explanation of why standards have fallen and achievement scores have declined.

The erosion of the school's authority has not passed unnoticed by the students. They have demanded and received rights and privileges which in earlier days would have been denied. Whether these greater freedoms have enhanced the educational achievement of children and youth is doubtful. That it has contributed to the difficulties and frustrations of maintaining a sound learning environment is scarcely to be denied.

As a further index of problems in this area, the field observers reported high rates of absenteeism, students wandering the halls, and a flagrant example of student disrespect for the teacher's authority. Although not reported in these studies, actual physical abuse of teachers has occurred on a fairly wide scale. Verbal abuse of teachers is a daily occurrence in many schools.

Such counterproductive conditions should certainly not be allowed to continue to prevail. It is a major educational problem when in the name of freedom and individual student rights, conduct must be tolerated that adversely affects the learning environment to the detriment of students who really wish to learn.

It seems clear that the notions of freedom and individual rights for students have often been extended far beyond any reasonable limits and as a result have often seriously impaired the ability of the schools to maintain an atmosphere conducive to effective learning. It seems clear that such freedoms are neither in the best interests of students nor of society. There is also a question of the rights of teachers to be accorded the respect, dignity, and consideration to which their office should entitle them. A recognized world authority on learning has made some pertinent observations about the impact of excessive freedom for students in the educational setting.

> Is the free and happy student at least more effective as a citizen? Is he a better person? The evidence is not very reassuring. Having dropped out of school, he is likely to drop out of life too. It

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[27] Case Studies in Science Education, Volume II, op. cit., Chapter 14, pp. 12-13.

would be unfair to let the hippie culture represent young people today, but it does serve to clarify an extreme. The members of that culture do not accept responsibility for their own lives; they sponge on the contributions of those who have not yet been made free and happy--who have gone to medical school and become doctors, or who have become the farmers who raise the food or the workers who produce the goods they consume.[28]

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The natural, logical outcome of the struggle for personal freedom in education is that the teacher should improve his control of the student rather than abandon it. The free school is no school at all. Its philosophy signalizes the abdication of the teacher. The teacher who understands his assignment and is familiar with the behavior processes needed to fulfill it can have students who not only feel free and happy while they are being taught but who will continue to feel free and happy when their formal education comes to an end. They will do so because they will be successful in their work (having acquired useful productive repertoires), because they will get on well with their fellows (having learned to understand themselves and others), because they will enjoy what they do (having acquired the necessary knowledge and skills), and because they will from time to time make an occasional creative contribution toward an even more effective and enjoyable way of life. Possibly the most important consequence is that the teacher will then feel free and happy too.[29]

Peer Pressure

The fact that the majority of teenagers do not place a high value on education has penetrated deeply into the teenage culture. Although the studies do not refer pointedly or frequently to this problem, evidence of its existence does show up in a few instances.

Although the adverse impact of these pressures is probably greatest on minority children, on children of poverty, and on children from lower-class homes, all children are subject to peer influences. It is notable that the references to to the peer pressure problem in the studies pertain in every instance to children who are either minority or with low social status. In one instance the observer reported that "the cost of being interested in education and valuing what the school has to offer is that it had cut Helena [the student] off from the social life that permeates school for most students."[30] In another instance the reporter stated, "They call Carmen 'Jaitona' (snotty) and other names."[31]

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[28]B. F. Skinner, "The Free and Happy Student," Phi Delta Kappan, September 1973, p. 14.

[29]Ibid., p. 16.

[30]Case Studies in Science Education, Volume I, op. cit., Chapter 11, p. 38.

[31]Case Studies in Science Education, Volume II, op. cit., Chapter 16, p. 26.7.

In still one more instance it was stated of students in a ninth grade class "some who aren't so bright and others who are bright are so heavily into the 'street' system of social relations and so under peer-dominated social control that they are lost to the activities of the classroom."[32] In the case of both teenage girls mentioned above, they were minority students. These incidents reflect the considerable social pressures exerted on such children in trying to ensure their conformity by nonachievement. The price of academic success was ostracism by their peer group. Few children have the strength of character and the sociological and moral supports to withstand this kind of pressure. Thus, a major problem appears to be how one might reorient the peer group (a difficult task) or, alternatively, how one can help such students to maintain their goals and aspirations and to protect them from the sometimes rather savage assaults of their peers.

The pressure to conformity by peers is also illustrated through another incident reported in which a student made an unorthodox but not necessarily incorrect response to a teacher's question. The student was ridiculed and laughed at and even though the teacher in this instance had regarded it as a "beautiful" and creative response, he did nothing to protect the particular individual from being embarrassed by his peers. It might be argued that it is a reasonable responsibility of the teacher to look for the rare, creative and insightful response and to rise quickly to the defense of students who make such responses and thereby create a climate in which "the unorthodox" idea can not only be stated, but be encouraged.

Teachers

The heart of the instructional process is the teacher. In emphasizing the importance of the teacher one worker made the following observation:

> Teacher Is Key. What science education will be for any one child for any one year is most dependent on what that child's teacher believes, knows, and does--and doesn't believe, doesn't know, and doesn't do. For essentially all of the science learned in the school, the teacher is the enabler, the inspiration, and the constraint.[33]

It is an irony of education that when teachers were regarded as low-paid menials their control over children and the educational process in general was almost absolute; yet, as teachers have approached a more nearly true professionalism, the controls teachers may exercise over students particularly, and to some extent over curriculum and teaching materials, has been gradually eroded. Teaching today is not a particularly happy occupation and any observer of the profession over a period of time is continually distressed by the exodus of many fine teachers to other occupations. Yet this is not surprising when one

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[32] Case Studies in Science Education, Volume I, op. cit., Chapter 9, p. 5.

[33] The Status of Pre-College Science, Mathematics, and Social Studies Educational Practices in U.S. Schools: An Overview and Summaries of Three Studies, op. cit., Chapter 19, p. 1.

considers the frustrations that teachers must endure in the present educational setting.

Teachers encounter pressures from all kinds of special interest groups and parents. There are demands for accountability, teacher evaluation and voluminous records and reports. Additional problems include inadequate materials and supplies, poor maintenance for equipment and insufficient time to accomplish all of the assigned responsibilities. Considering all of these many factors it is no wonder that teachers are not highly enamoured with many of the curricular innovations that are presented to them. No wonder, either, that teachers are occasionally hostile toward "scholar's help."[34] In spite of all these problems, however, there are many excellent teachers who can and do conduct first-class educational programs. Unfortunately, their number is insufficient.

Teacher Assignment and Misassignment and Related Problems

The studies provide some insight into one of the most grievous problems in American education. It is also one that gets some of the least exposure. This relates to the assignment of teachers, particularly at the junior and senior high school levels. There are assignment problems in the elementary school but they are of a different order. With regard to secondary school teachers, one hears a great deal about the poor teacher preparation encountered. If one probes beneath the surface, however, the problem is often not lack of preparation but of misassignment. The data reported in the three studies give ample evidence that misassignment is a very real problem and a common phenomenon. That there are administrative problems in making appropriate teacher assignments cannot be denied. There is always an overflow section of English, algebra, American history or other subjects that has to be taught. Nevertheless, there are too many instances where teacher assignments do not reflect this kind of administrative necessity but, rather, result from inept recruiting, poor management, lack of planning, or other extraneous factors.

The problems are now intensified because many schools are faced with reductions in force and retention and reassignments are made on the basis of seniority rather than on curricular needs or professional qualifications. One teacher reported that half of the mathematics teachers in his school were really social studies teachers.[35] In other instances, the intent of affirmative action seems clearly to be circumvented and a field observer reported that in certain sites they found "kith and kin" considerations to be highly significant in teacher employment. Somehow or other it seems that this type of provincialism should be passé.

Evidence presented in the Research Triangle Institute study indicates that in the junior high schools only 28% of the mathematics teachers, 24% of the science teachers, and 24% of the social studies teachers had teaching assignments restricted to these fields only. The comparable figures for senior high schools

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[34] Case Studies in Science Education, Volume II, op. cit., Chapter 16, p. 2.
[35] Ibid., p. 26.5.

were 27% for mathematics, 27% for science, and 31% for social studies teachers.[36] Unfortunately this information is not very useful since no evidence is provided about teachers' academic and professional preparation. It may well be that they have teaching assignments in mathematics only and yet be minimally prepared in the field. The presumption probably is that most of these people were teaching in their major field but there is no evidence submitted to demonstrate that this is, in fact, so. It is certainly well known that a great many teachers are teaching outside of their major fields of preparation. Perhaps the most important question is not whether they are teaching in more than one field but rather how adequate the preparation may be to teach whatever it is they are assigned to teach. There might be a reasonable expectation, for example, that a physics teacher would be competent to teach an introductory algebra course.

It is perhaps significant also to point out that only somewhat over 5% of school principals have backgrounds in mathematics and approximately 10% have backgrounds in natural science.[37] This in itself might give some clue to the lack of emphasis or focus in many schools on academic programs including those in science and mathematics. It may also raise serious questions about communities' values and the relative values they assign to academic programs versus other school activities.

Preservice Training of Teachers

None of the studies gives much information about the preservice training of teachers although they tend to emphasize that, especially in the 1960s, attention was focused on inservice education to the neglect of preservice concerns.[38] This appears to be one of the major gaps in the reports. Yet good preservice programs are the best insurance for qualified teachers. It is much more difficult to correct deficiencies, particularly in the academic backgrounds of teachers once they have been certified, than it is to require adequate preparation prior to certification.[39] As previously indicated, the quality of much that passes for inservice education is of dubious value and is hardly likely to compensate for major deficiencies that may exist in the preservice programs. Although accreditation standards of various kinds have helped to ensure some measure of quantitative control--specific courses, number of credits, etc.--accreditation rarely touches upon the qualitative aspects of programs either in the content teaching areas or in the professional educational components.

Although many criticisms have been made of teacher preparation programs, the facts are that almost no major teacher preparation institution would graduate and recommend a social studies student for certification as a teacher who did not have a broad background in the social sciences including the equivalent of a major in one field with supporting courses in such areas as geography, sociology, economics and political science. If the major should happen to be in one of these fields, then substantial work in American history and a selection of non-American history courses would be required. Similarly in biology, a teacher

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[36]Weiss, op. cit., p. 46.
[37]Weiss, op. cit., p. 143.
[38]Suydam and Osborne, op. cit., p. 130.
[39]Suydam and Osborne, op. cit., p. 166.

recommended for certification would typically have a sound grounding in botany, zoology, and physiology, with required courses in genetics, organic and inorganic chemistry, microbiology, etc. Other fields tend to show a similar pattern with adequate distribution and depth in appropriate courses, at least to the extent that such distribution and depth can be acquired in a four-year baccalaureate program of studies. It must be reiterated, however, that no preparation program can compensate for faulty teacher assignments.

Probably one of the most serious preservice problems in science relates to the preparation of elementary school teachers. Elementary school teachers are reported to indicate that they have the greatest feelings of inadequacy with respect to teaching science.[40] This is surely partly a reflection of their preparation. Often as few as six hours of science may be required, which is likely to be a general survey type of college course or the introductory courses in a major field. However, the number of hours is not necessarily an index of quality. College science courses provide practically no preparation of the kind that would be useful to the elementary teacher in the classroom. The professional preparation component of the teacher's education tends to focus heavily on the teaching of reading and mathematics, especially reading. Professional preparation to teach science may be minimal. The AAAS in cooperation with the state directors of teacher certification has been active in addressing the problem of teacher preparation.[41]

The Ohio State University study reflects some serious problems with respect to junior high school teachers. Few teachers prepare specifically to teach junior high school science. Most junior high school science teachers have been prepared to teach senior high science and thus have specialized in biology, chemistry, or physics. Junior high science is usually a mix of disciplines. Ideally it should address the unique psychological and social needs of early teenage children and junior high science teachers should be specially prepared for this important task. Preparation programs focusing particularly on teaching at this level are comparatively uncommon, although there has recently been some enhanced interest shown by teacher preparing institutions. The Ohio State report indicated that in 1968 there was a lack of basic objective evidence on the effectiveness of teacher education programs.[42] This situation still prevails. There is no doubt whatever that many institutions of higher education have teacher education programs but do not have either the commitment or the resources to prepare quality teachers.

In the senior high school it appears that problems at this level, as far as formal preparation is concerned, are much more likely to be identified with the misassignment of teachers than with the formal preparation in their specialized subject field. The same questions of quality and relevancy of the typical academic major to the realities of teaching in secondary schools still prevail.

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[40]Weiss, op. cit., p. 142.

[41]American Association for the Advancement of Science, Preservice Science Education of Elementary School Teachers, 1970, and Guidelines and Standards for the Education of Secondary School Teachers of Science and Mathematics, 1971.

[42]Helgeson et al, op. cit., p. 69.

Another issue that needs to be faced squarely is the relationship between the amount and quality of the teachers' professional and academic preparation and the performance of their students. The small amount of evidence submitted in these studies is not reassuring. It was indicated that neither years of experience nor advanced training was significantly related to differences of frequency of use of good reading practices.[43] In another instance it was reported that research workers "found that there was no correlation between formal subject-matter preparation and teacher knowledge of the subject or between formal subject-matter preparation and student cognitive learning."[44] In reviewing the research on mathematics teachers and the results of some major studies, it was reported that "the teachers' characteristics did not account for a significant portion of the variance"[45] (in student performance) and there was "no significant correlation between teachers' knowledge and performance of their students."[46] Such findings raise serious questions about the nature of both preservice and inservice training programs and about both the professional and academic components of preparation. There are certainly a number of alternative explanations that might be considered in exploring this phenomenon if further evidence establishes its general validity. It may be that once a minimum competence in subject matter is attained, other abilities such as those pertaining to communicator, facilitator or motivator roles may become more important. Thus a minimally prepared teacher might be equally or more successful than a colleague with more substantial academic preparation who lacks personal qualities or traits useful in the classroom. Or it may be that teacher preparation is such a minimal factor in the psycho-social setting of the school that it contributes relatively slightly to the total variance in student performance. Still a third possibility is that preservice and inservice programs are just not relevant in terms of the selections of subject matter and methodologies that are appropriate to elementary and secondary school teachers' needs. Whatever the case, it would appear that this is a major problem and one deserving of some serious exploration by research workers. Obviously, the debate and concern about both pre- and inservice education for teachers can be meaningful only in the context that such training does make a difference in the learning and performance of their students.

Inservice Training of Teachers

The concept of inservice education covers a broad spectrum of activities that vary greatly both qualitatively and quantitatively. The report from Ohio State states, "inservice education appears to mean different things to different people, with little agreement concerning its purposes."[47] One of the criticisms teachers make of inservice education is that it is not "job specific." Locally designed inservice programs for the purpose of introducing a new curriculum might very well be highly specific job-related learning.

On the other hand, graduate courses at a university are presumably looking at broad concepts, principles, and problems in the field. They should be useful

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[43]Wiley and Race, op. cit., p. 58.
[44]Ibid., p. 161.
[45]Suydam and Osborne, op. cit., p. 144.
[46]Ibid.
[47]Helgeson et al, op. cit., p. 70.

to the teacher but in a more general sense. They would require translation, adaptation, and filtering to make them applicable to the specific needs of individual elementary and secondary classrooms. A professional teacher should be able to make such a translation.

In general the teachers surveyed felt that the National Science Foundation Institutes were moderately successful to successful.[48] There is a tendency to lump all of the NSF Institutes into a single stereotyped category in the studies. Like other stereotypes, this is subject to question. Undoubtedly the institutes varied enormously in their quality and value. There is not much doubt that teachers would like to see them continued, although there were occasional criticisms of the programs. One cannot avoid considering the possible self-serving motives involved in the positive evaluation made by many teachers who hoped that good ratings might encourage reestablishment of the programs.[49]

One of the criticisms of the institute program was that generally they tended to serve teachers who needed inservice training least.[50] On the positive side, the institutes served a very large proportion of the present leadership cadre in science education and provided them with experiences and perspectives that they would otherwise have been unlikely to acquire.

Curriculum

The last 25 years have witnessed unprecedented activity in the field of curriculum development. The aftermath of World War II, Sputnik, the Cold War, the support by the federal government of various curriculum reform endeavors--with generous support of many millions of dollars--an accelerated rate of technological development, student activism and various aspects of social reform have profoundly influenced the curricula of the schools. School curricula have been influenced by currents and counter currents including liberal and conservative ideologies, innovators and traditionalists, accountability adherents, promoters of management by objectives, elitist versus populist philosophies, and advocates of technological applications to education. Considering all of these forces seeking to change the educational curriculum, it is not much wonder that the school curriculum sometimes appears to be in disarray.

Curricular Innovations

No period in American history has witnessed the introduction of so many educational innovations, particularly in science, social studies, and mathematics, as the last 25 years. There are those who feel that the innovations were introduced with "insufficient rationale for sweeping changes in curriculum and instruction."[51] One of the problems has been the definition of "change." Change may be revolutionary--change with a capital "C"--or evolutionary--change with a small "c." Even the most conservative educator recognizes that neither

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[48]The reference is to the NSF-supported summer and inservice institutes for precollege teachers that were a major effort of NSF in the 1960s.

[49]Suydam and Osborne, op. cit., p. 167.

[50]Ibid., p. 136.

[51]Ibid., p. 59.

curriculum materials nor teaching practices can maintain a status quo position. Improvements are always needed in education. But, as the Ohio State review indicates, there is a feeling that "far too many of them [new instructional approaches] have been promoted as panaceas, rather than as components in a teacher's repertoire, to be used as children, content, and circumstances warrant."[52]

"Reform" Efforts Supported by NSF

The reform programs sponsored by NSF have been perceived by some to be in the elitist tradition. They reflected a philosophical position that science is an investigative and logical search for order and that content should be selected and instructional materials developed in accordance with this concept. They were difficult and they were demanding on both teachers and students. The emphasis was on structure of the subject matter and much of the content was abstract, perhaps most markedly so in the so-called "new mathematics." However, the NSF-supported reform efforts started just before or just after the launching of Sptunik in 1957 and were a response to the concern that the United States needed more scientists to compete with Russia. The new curricula were conceived of as elitist. Then in the late 1960s and early 1970s national concerns were refocused on such things as relevance, job-related learning, consideration of opportunities in science for all members of society, and limitations and problems of technology. These "deficiencies," evident in the reports, do not reflect on the purpose of the NSF-supported curriculum projects, but rather on the change in direction of the purposes of elementary and secondary science, social science, and mathematics education.

The NSF-supported curriculum projects have had a strong positive effect on precollege education. Perhaps the greatest value is in the influence that they have had on instructional materials produced by publishing companies. It is probably the case that commercial materials have been substantially improved either through the need to compete more favorably or through emulation, imitation, and/or stimulation provided by the NSF-sponsored materials. No doubt certain materials and practices were also avoided on the basis of observations of problems with the project materials. Such influences will probably continue for many years into the future.

Elementary School Science

Many factors have converged to contribute to a diminishing role for science and social studies in the elementary school. After the flurry of activities to promote science and social science education in the elementary schools during the '60s, there has been a gradual decline in emphasis and time devoted to the subject.[53] Factors contributing to this situation are numerous and include the inadequate preparation of elementary teachers in science and the decline in student achievement which further stimulated the very strong "back to the basics"

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[52] Ibid., p. 58

[53] The Status of Pre-College Science, Mathematics, and Social Studies Educational Practices in U.S. Schools: An Overview and Summaries of Three Studies, op. cit., Chapter 19, p. 3.

movement along with demands for accountability and competency, especially in regard to reading and mathematics. The view is widespread and supported by junior and senior high school science teachers that perhaps science is really not very important in the elementary school.[54] One thing that is not clear from a philosophical point of view or from any evidence included in the three reports is why science vocabulary, facts and elementary ideas and concepts of science cannot be used as a vehicle for the reading process and for correlation with school mathematics. This is a point that deserves serious consideration by school systems and other groups concerned with the quality of precollege science, mathematics, and social science education.

The reports indicate strong negative reactions by teachers toward the moving down of difficult materials from higher grades into lower grades. They resist the notion that better instruction means harder instruction and by implication they see such efforts as only increasing their difficulty in keeping students motivated and responsive to the instructional process.[55] This is another point that should be considered seriously. Is the implication justified? Do teachers need inservice orientation?

The "back to basics" movement is a fundamental determinant of elementary school curriculum today. By some, science and social studies are not included among these basics, although why they are not is a pertinent question. Scientific concepts such as time, distance, gravity and life-maintaining requirements of the living organisms are among the most basic ideas that one can imagine. The fact that natural science is not considered "a basic" is probably a reflection of some of the misconceptions held about the sciences by society at large.

"Back to the basics" is supported by some teachers who appear to be convinced that improvement in science education and in other fields is directly related to reading ability and ability to do mathematics. It is hard to fault teachers for such a view since reading and mathematics represent enabling skills basic to [redacted] other scholarly attainments. Very often the skill of writing tends to be om[redacted]ed in the modern concept of "basics."

Readi[redacted] must have some content and it is hard to understand why some reading content cannot be based on science.

One of the interesting ideas that emerged from the case studies report was that inquiry does not appear to [be] work![56] Anyone who has ever engaged in serious inquiry realizes that nothing could be further from the truth. How, then, does such a perception emerge? Possibly it may be a reflection of the poor use of inquiry techniques as they were observed in the cooperating schools. It may reflect the poor discipline or at least the considerable disorder that sometimes prevails when students are involved in inquiry-type lessons or it may merely be that productive activities were in progress which were not readily discernible to the case study observer. Perhaps students were having "too much fun." Whatever the explanation might be, it is unfortunate that such a view prevails and

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[54]Ibid., pp. 2-3.
[55]Case Studies in Science Education, Volume I, op. cit., Chapter 1, p. 40.
[56]Case Studies in Science Education, Volume II, op. cit., Chapter 12, p. 7.

it gives credence to and support for more low-level drill type activities which underlie a "basics" philosophy. There seems to be a common acceptance of the notion that hard work is good work. It may in fact of course be nothing of the sort. While it certainly is legitimate for the schools to emphasize that outstanding achievement requires hard work, there seems to be a transformation of this idea to the unacceptable "any hard work is good work."[57]

Secondary School Science

Secondary school science education seems to lack a sense of direction and a theory and philosophy which should provide guidance to curriculum development and instruction. This may, in part, reflect the "elitist" philosophy of the curriculum development projects of the late 1950s and early 1960s. In reference to the natural sciences, the reviewers at Ohio State University stated that in their opinion "it appears that the role of science in the secondary school curriculum for general education remains unclear. What science students should learn also remains unclear."[58] The Panel who advised the writer of this report concurs with this observation, but suggests that it may have applicability beyond the natural sciences and that it is time for the development of a coherent philosophy and the establishment of directions for all science education.

It seems doubtful that there has ever been a time in which there was so much uncertainty about the purposes of education. What constitutes an appropriate general education for all seems now to be in unpleasantly obscure question. The purpose of education has been explored from the times of the ancient Greek philosophers down to the present time. Herbert Spencer's essay "What Knowledge Is of Most Worth?" explored the topic.[59] More recently the Educational Policies Commission of the National Education Association has issued statements relating to the general purposes of education in American society. Although such statements may still be valid, they no longer serve as guides and compasses. The three studies suggest that now is the time to look sharply at the purposes of education to our society and particularly to the role of science, mathematics, and the social sciences in the education of American citizens.

The curriculum projects of the sixties, for reasons made clear earlier, did not address the problem of general education.[60] One of the strongest criticisms made by the reformers of the then existing science programs was that there was too much emphasis on technology. It was their contention that what was really needed was more attention to the "pure" science. In their view, this was urgent because of the Russian success with Sputnik and the general high level of Russian technological advances. What they were interested in was training high grade professional scientists who could advance technologies related to nuclear energy, space exploration, oceanography, and so on, that would enhance defense systems and national security.

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[57]Ibid., Chapter 16, p. 16.

[58]Helgeson et al, op. cit., p. 37.

[59]Herbert Spencer, "What Knowledge Is of Most Worth?" Education, E. L. Kellogg & Co., New York, 1892, pp. 5-69.

[60]Case Studies in Science Education, Volume II, op. cit., Chapter 12, p. 1.

The new science curricula funded by NSF did not address technologically based problems or the problem solving techniques necessary for developing solutions. Students did not learn of the relationship between science and technology, hence they were unaware as future citizens of the roles that research and development play in an industrial nation and the trade-offs and side effects that would affect them individually and collectively. These were not a part, nor were they intended by the curriculum developers to be a part, of the curriculum developments of the 1960s. Clearly future curriculum developers need to be concerned about introducing social implications of science into the secondary school curriculum.

Course Sequences

There is no generally recognized sequence of courses at the junior high level in any of the science fields. At the senior high level, the sequence of biology, chemistry, and physics seems to be rather firmly fixed in the natural sciences but tends to be restricted to the group of students bound for college. For the non-college bound, biology is typically the last and only science taken at the upper secondary school level.

Both junior and senior high schools most frequently offer American history, although the content is sometimes included under the general rubric of "social studies." Other social science courses most commonly offered in the senior high school are world history, American government, and sociology.

In mathematics a fairly definite sequence of 7th and 8th grades mathematics, 9th grade (in some cases 8th grade) algebra, 10th grade geometry, 11th grade advanced algebra, and 12th grade advanced mathematics (trigonometry and calculus in some cases) can be identified for college preparatory students. Many other kinds of mathematics courses are also offered for students with different objectives.

In large school systems all three subject areas are represented by a variety of elective courses which may reflect accommodation to either low or high ability students, specialized academic or vocational interests or the use of local specialized resources. Electives include such courses as physiology, astronomy, zoology, advanced biology, and advanced chemistry among others in the natural sciences; black history, law, economics, geography, and psychology among others in the social studies; and probability and statistics, computer mathematics and business mathematics among others in mathematics.[61]

The Articulation Problem

The problem of what ought to be taught, to-whom, and when, is one of the chronic dilemmas of education. Fitting a twelve-year educational program together so that the basic facts and concepts come in an appropriate sequence is the problem of articulation. The evidence submitted in the three studies reviewed

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[61]Weiss, op. cit., p. 59.

indicates that articulation problems are widespread.[62] Schools have apparently not succeeded well in developing a coherent, articulated program of instruction. Articulation is most pressing in a highly ordered and sequential field such as mathematics. It is less so in science and still less so in the field of social studies. Nevertheless, there is a need and a value of sequencing even in a less structured field such as social studies since instruction can be more efficient and more can be accomplished. Students also have an equity in articulation because of the difficulties which they may encounter when they transfer between schools or between school systems and find themselves placed in classes for which they do not have adequate preparation. Obviously there is a need for articulation between grade levels.

Some of the factors contributing to poor articulation include the autonomy, interests and qualifications of the individual teacher, nonsequential instructional materials, lack of communication between teachers and between educational units, particularly between the elementary school and junior high school and between junior high and senior high schools. Failure to solve these problems results in students who complain bitterly that they have had the material before and they find it boring and unmotivating, or that they are lost because they do not have the needed background. Teachers often counter with the observation that they may have had it, but they did not learn it, or conversely, that they must catch up.

There are curious inconsistencies with respect to the problem of articulation. Teachers have a disposition to "cover the material" and to justify their work as preparation for work to be taken in subsequent grades. Strangely enough teachers in these subsequent courses seldom believe that the material has been thus; although there is a widespread "preparation ethic" it does not seem to be consistent with the apparent widespread lack of articulation.

Textbooks

One of the field workers (CSSE) pointed out that the heart of the instructional process is the instructional materials.

> Behind nearly every teacher-learner transaction reported in the CSSE study lay an instructional product waiting to play its dual role as medium and message. They commanded teacher's and learner's attention. In a way, they virtually dictated the curriculum. The curriculum did not venture beyond the boundaries set by the instructional materials.[63]

In the great majority of cases, the instructional materials are provided by the textbook. Despite the lamentations of academicians, professors of education, curriculum developers and others about textbook oriented instruction, the practice has continued to prevail and flourish. When a practice continues so long in the face of long standing and severe criticism by outstanding educational leadership, it may be desirable to examine the practice in considerably more

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[62] The Status of Pre-College Science, Mathematics, and Social Studies Educational Practices in U.S. Schools: An Overview and Summaries of Three Studies, op. cit., Chapter 19, p. 7.

[63] Case Studies in Science Education, Volume II, op. cit., Chapter 13, p. 66.

more detail. Why have textbooks had such an enduring quality in the educational process?

From the teacher's view there are a great many positive aspects to the use of a textbook. A textbook provides a structure and an outline of content. As indicated in the section on teachers, time is indeed a precious commodity and teachers never have enough of it. The textbook makes minimal requirements on the teacher's time, provides a base reference for course requirements which must be met by students and minimizes the teacher's need to prepare special handouts or other types of instructional material. Its use is expected by parents and community, and it is not likely to be questioned as to authenticity or appropriateness. In short, teachers look upon the textbook to provide structure, continuity and a reasonable selection and boundary of the content which should be taught and as a backstop for questions that may be raised by school patrons. Packet and loose-leaf materials, teacher-made materials, etc., are far more difficult to keep organized. They increase still further the demands on the teacher's time through greater bureaucratic and administrative duties. They also require adequate support staff (clerks, secretaries, aides) which is often not available. If this is a reasonable analysis, then perhaps it is appropriate to look at the manner in which textbooks might be used more effectively since it appears that they will be a fixture in education for a long time.

Many of the historical criticisms that have been made of textbooks have related more to the manner in which they have been used than to the textbooks themselves. Very often textbooks have been used in a manner never intended by the author. They have too often been used in a catechetical fashion rather than as a dependable source of information for use as a point of departure for further interesting discussions or other follow-up activities. They have often been used as a basis for rote learning with the result that instruction has been barren and dull. Too often there has been a lack of application of textual materials in ways which are meaningful to the students. The instruction has not been personalized, embellished or embroidered by additional examples or illustrations which could be related to the individual lives of students. Thus, it is a logical conclusion that if the textbook is to remain as a central feature of the educational process, strenuous efforts are needed to make the use of such an instructional resource far more effective than it has often typically proven to be.

Laboratory Instruction

One of the insightful paragraphs in the case studies related to the changes which have occurred is the concept of what constitutes laboratory work.[64] It is pointed out that new science topics in the curriculum create problems for laboratory and demonstration work. Many of them do not lend themselves easily to the traditional formula which required the arrangement of material or equipment, the observation of phenomena, appropriate recording of observations, interpretations, conclusions, etc. The observer pointed out further, that such activities as working with structural models of molecules, studying eco-systems in the field, maintaining a balanced aquarium, developing a film or prints and constructing an

[64] Case Studies in Science Education, Volume II, op. cit., Chapter 13, p. 9.

electronic circuit, all lack adaptability to the ordinary "formula" of laboratory instruction. This observation prompted a reporter to ask "If the format changes to accommodate these interests, then where is the rigor of scientific method?"[65]

As part of the intellectual revolution which the curriculum reformers of the '60s were seeking to promote in the science curricula was an emphasis on the processes of science. Students were to experience these processes primarily through discovery techniques usually labeled as "inquiry." If these three studies are any indication, quality inquiry type instruction is a rare occurrence. Testimony seems to indicate that only the most gifted students are able to profit from this type of an approach to any considerable extent.[66]

Whatever may have been the merits of this approach there are clearly a number of factors that make its implementation difficult. Perhaps the largest obstacles are in the demands placed upon the teacher. The problem of classroom management becomes a problem since it is more difficult to maintain discipline and to keep many children busily engaged in productive work. Furthermore, materials must be assembled and prepared for the lesson and they must be collected and stored following the lesson. The demands for help from floundering students places great demands on the teacher during the instructional period.

There are probably other more subtle reasons why the inquiry approach to instruction is difficult from the teacher's perspective. For one thing, it puts the teacher in a more open-ended and uncontrolled situation and students are likely to raise questions which are very difficult to respond to effectively. For the minimally prepared teacher, especially, such situations are likely to pose real threats to their own self-image and sense of adequacy. Perhaps even more significantly, there is a standard expectation from students, parents, and the community at large that teachers "will know the answers." The teacher-as-authority is deeply ingrained in American folklore and any thing or process that appears to threaten this stereotype is likely to be challenged. The promotion of self-directing skills and a skeptical approach to knowledge is also contrary to the historic submission-authority stance of the schools with respect to students.

From the student's perspective, even a conscientious one, there are also problems. Students have been rather thoroughly conditioned to a deductive approach to learning. Any kind of inductive learning, of which inquiry teaching is clearly an example, is likely to be seen as an unaccustomed mode of learning and one that is not particularly appreciated. Most students are "looking for answers" and usually are not caught up in the niceties of the processes involved in obtaining or testing the validity of knowledge. They are likely to view inquiry procedures as "beating about the bush." Admittedly, some teachers can make inquiry techniques work and can change student perspectives. But such a teacher is indeed a rara avis.

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[65] Ibid.

[66] Case Studies in Science Education, Volume II, op. cit., Chapter 12, p. 7.

From still another perspective, the use of inquiry methods is artificial and open to challenge. It may be unreasonable to expect students to sort out data and manipulate materials in ways that enable them to reach conclusions or make observations that were originally discovered and explained by mature individuals with the best minds. Inquiry methods also raise the question of the efficiency of instruction since they are time-consuming and certainly any large-scale implementation of such a program will severely restrict the amount of coverage that can be expected. Advocates of inquiry techniques will reject this particular view on the ground that skills and insights gained are more important than coverage geared to teaching programs. But this rejection will not impress many teachers who are concerned about the broad implications of local, state, or national assessment programs and their relationship to accountability and the teacher's own evaluation.

Finally it seems highly probable that the inquiry mode is not an efficient method of learning for a great many children, sometimes even gifted children. Many students seem likely to profit much more from a structured approach even though some exposure to inferential reasoning seems highly desirable.

Whatever may be the reasons, and several possibilities have been suggested in the paragraphs above, it is apparent that inquiry teaching has not been very successful in the classroom in the American schools based on the evidence submitted in the reports reviewed. One bit of documentation provided for this observation is to be found in the Research Triangle Institute report which indicates that manipulative materials are used less than once a week in more than half of all science, mathematics and social science classes. Even more distressing is the report that 9% of science classes never use manipulative materials and another 14% do so less than once a month.[67]

It is apparent that not only inquiry but more traditional laboratory work requiring "hands on" activities is not as common as might be desired.

Teaching Resources

It is curious to note that the question of resources for the teaching of sciences was never addressed directly and completely in any of the studies. Bits and pieces of the resource story trickle through each study, however, and the story is not a happy one. Budget and financing problems are identified repeatedly as the most serious faced by the schools.[68] Declining enrollments, increasing costs, taxpayer revolts and the shrinking value of the dollar are all cutting heavily into the financial resources of the education system. Of all the academic areas of the curriculum, natural science education is hardest hit. This is so because of the experiential, manipulative nature of science programs. While the federally funded innovative curricula designed and developed by teams of experienced scientists and educators called for student activity and the extensive use of concrete materials and experiences, local school system budgets were altered

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[67]Weiss, op. cit., p. 107.
[68]Helgeson et al, op. cit., p. 133.

slightly, if at all, to accommodate this approach to the learning of the natural, social, and mathematical sciences.

Teachers of the natural sciences in particular have reported inadequate funds to operate laboratory and field programs and have indicated a special need for funds to purchase supplies on a day-to-day basis.[69,70,71] A high level of frustration is experienced by them in attempting to prepare, maintain, repair, inventory, order and clean up materials and equipment in addition to lesson planning, teaching and evaluating. These duties must be performed without the assistance of paraprofessional help.[72]

It is the writer's experience that the U.S. is almost alone in the world in this neglect of the necessary support staff for successful science teaching. Teachers and science educators in other parts of the world are appalled when they learn that the American science teacher is expected to manage without a laboratory technician or other paraprofessional help. Such personnel is considered essential in most other countries, including developing nations.

Some Implications

The three studies are provocative and raise serious questions about many aspects of both education in the sciences and education in general in the public schools of this nation. The nature of the studies was such that many equally important problems were either not touched at all in the studies or were alluded to only in passing. The studies are rich ground which should be plowed in the future for implications of missing questions as well as for those that are included.

National and Local Perceptions of the Educational System

The studies reflect a difference between the perceptions of the national government and of local governments of how schools ought to operate.[73] Many national vs. local perceptions can be considered as paired opposites. Some suggested paired-opposite terms which could be used in helping to clarify these perceptional differences might be: "ideal" versus "practical" solutions, "long term" versus "immediate" goals, "dollar effectiveness" versus "educational effectiveness," "academic discipline" versus "student learning" orientation, "individual student rights" versus "needed social controls," and "theoretical principles and solutions" versus "flesh and blood realities." Other paired opposites could be selected to illustrate some of the perceptual differences at the two levels. Such differences are sources of confusion, controversy, disruption, and hostility.

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[69]Weiss, op. cit., p. 126.
[70]Case Studies in Science Education, Volume II, op. cit., Chapter 13, p. 4.
[71]Weiss, op. cit., p. 135.
[72]Ibid.
[73]Case Studies in Science Education, Volume II, op. cit., Chapter 17, pp. 1-2.

The large-scale intervention of the federal government in education is a relatively new development and the regulations and controls which have accompanied the federal dollars have run headlong into one of the most cherished of national traditions, namely, local control of the schools. Local control has historically been eulogized as a typically American innovation and one which insured that the schools would be kept "close to the people." The recent trend to reverse such a long established educational doctrine could certainly be expected to generate antagonism.

The developers of the NSF-supported curriculum projects in the 1960s failed to give adequate consideration to many of the historic traditions in American education and to the social settings in which public schools must operate. The constraints related to budgets, teachers' time, equipment, bored and unmotivated students, community pressures and other factors not seen as formidable obstacles to implementing new programs.

There was also a considerable bit of scapegoating at the time and schools of education were frequently identified as the culprits responsible for all that was wrong with American education. There is still some evidence of the continued existence of the view in some agencies and some legislatures that colleges of education cannot be trusted. This is evidenced by providing support for inservice training activities of teachers in non-college and -university related centers and by other similar actions which tend to bypass teacher training institutions. It is interesting to consider what the long-range qualitative implications of such developments may be. The main point however is that the developers of the curriculum projects tended to ignore the existing power structure. It was certainly their intent to bypass colleges of education and, to a lesser extent, state departments of education in their efforts to reform the curricula of the schools. The following excerpt supports this view.

> The projects had, in a sense, circumvented schools of education and gone directly to the elementary and secondary schools in their dissemination efforts; as a result, many methods professors had not had a chance to become familiar with the projects and had, in a sense, been made somewhat "obsolescent" by them. Further, the splitting up of the roles of developer and educator, which had formerly been combined in many methods professors who were both textbook writers and methods teachers, increased the uneasiness of the methods professors. Also the projects approach was at odds with a common conception held by methods professors, of the teacher as developer of his/her own curricula: ". . . methods teachers tend to want a kind of social studies that is not easily prepackaged."[74]

Although the committees and boards of directors responsible for developing the new programs were sprinkled with a few practitioners, and even an occasional science educator, policy control remained firmly in the hands of academicians. By now it is clear that the success of the reformers was only moderate. It is also obvious that not all of the shortcomings of public education can be laid at the doorstep of the schools of education. The implication is also evident that any future national effort should make use of the existing power structure and

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[74]Wiley and Race, op. cit., pp. 138-39.

seek cooperative working relationships with all those who may be legitimately involved. Had this been done, many mistakes might have been avoided and millions of dollars of federal money expended far more efficiently. Support for this position is found in the following paragraph.

> Policy formulation at the federal level typically has ignored existing practices in the schools except as mirrored in the disquietude of society. Information was collected after-the-fact of policy decision to confirm the actions taken. The amazing, significant conclusion indicated by this study is that progress has been made without systematic information collection about existing practices. Apparently, the societal/political ethos is sensitive enough to the goals, aims, and objectives of education to provide substantial direction. Thus efficiency in promoting change is the real problem to be faced. The implication is that not only must appropriate kinds of information concerning practice in the schools be collected: sound application of this information must be made.[75]

The Problem of Values

The nation has moved away from the historic sociocultural melting-pot concept in which presumably all minority groups would be eventually fully assimilated to the concept of a pluralistic society where cultural differences are not only tolerated but are to be cherished and perpetuated. The emergence of cultural pluralism as a national goal has contributed to the present anarchy in values. It seems to be tacitly assumed that, of course, values vary from culture to culture. What is frequently overlooked is that there must be large areas of overlap of values held by various minority cultures and the cultural mainstream. Presumably such common values as respect for the individual, personal integrity, and responsibility and concern for others are characteristic of many cultures. What these common areas are need to be identified. The differences, to the extent that they are socially disruptive, should also be analyzed and understood and their implications for education made clear.

A case is continuously made for tolerance and toleration of other people's values and actions, but even tolerance should have its limits. As a society we are certainly under no obligation to tolerate the values of the criminal subculture, for example. There is too much of a disposition to accept the notion that one value is as good as another and that any individual has a right to hold any values he desires. In spite of the prevalence of such a view, neither education nor society in general, can tolerate such value anarchy. Some of the reasons for concern about values has recently been summarized as follows:

> Values are important because they give direction and consistency to behavior. Man is a social animal and he lives in a social world and, therefore, his behavior has social consequences. We are fundamentally and ultimately concerned with the values which people hold

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[75] The Status of Pre-College Science, Mathematics, and Social Studies Educational Practices in U.S. Schools: An Overview and Summaries of Three Studies, op. cit., p. 30.

> because of the impact of values on individual and social behavior and social interaction. If this be true then some values have more social utility than others and individual man cannot unilaterally determine for himself what values he will hold. A democratic society cannot long endure value anarchy for values are the social cement which makes productive social intercourse a possibility.[76]

One of the results of the emergence of an emphasis on cultural pluralism is teacher uncertainty with respect to their appropriate role in the value orientation of youth. There has been a tendency to shun responsibility in this area.[77] Education has become much more thoroughly secularized, more "amoral," and allegedly "more value free."

Evidence of the impact of pluralism is apparent in the following citations:

> It is fairly clear why a higher level of constraint on the teacher, as far as the expression of individual values, may emerge in schools with a highly diverse population: the teacher's values conflict with those of at least some of the students.
>
> . . . . . .
>
> One result of heterogeneity was that teachers felt less influential in the guidance of children. As pressures constraining the teaching of values directly were reduced [sic: increased?], the teacher's perception of his/her function seemed to diminish toward one of relaying facts. At any rate, we often found that physics and chemistry were perceived as cut-and-tried collections of facts that could be adequately treated by simply relating them, without emotional connotations, without enthusiasm, without excitement, without creative insight.[78]

To the extent that teachers perceived the teaching of values as their responsibility, they tended to restrict their teaching to "safe" areas such as "study hard," "be a good subordinate," "work carefully," and "be productive." The Case Study reports tended to subsume the inculcating of such values under the general rubric of "pupil socialization." Although these are surely important, they ignore more important overarching values. It is not only what students know and can do; it also what they are disposed to do with such knowledge and skills and how these learnings can be related to the larger individual and social good.

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[76]Herbert A. Smith, Science Education: Past or Prologue, 1978 AETS Yearbook, Association for the Education of Teachers of Science, ERIC Information Analysis Center, Columbus, Ohio, p. 226.

[77]The Status of Pre-College Science, Mathematics, and Social Studies Educational Practices in U.S. Schools: An Overview and Summaries of Three Studies, op. cit., Chapter 19, p. 4.

[78]Case Studies in Science Education, Volume II, op. cit., Chapter 12, p. 32.

The question of values is a concern for all of education--not just science education. The question of values was implicit in many places in the case studies but explicit in only a few. The question of values in education is worthy of further study.

Some Action Imperatives

1. The contribution of science to the total general education of students needs immediate attention. This is important for all students. It is especially critical for those who will graduate from college and who will eventually assume leadership positions in business, industry, and government but who will not pursue study in scientific fields. One of the constant complaints of members of the scientific community is that key executive and legislative leaders do not understand their needs or the need for a continuing commitment to basic research. Whether better general education in science, which would explicate more fully the nature of science and its contributions to mankind, would accomplish the needed orientation for leaders in key positions who are not scientifically oriented as well as meet the needs of noncollege-trained citizens is perhaps uncertain. Nevertheless, the general education problem seems unsatisfactorily solved at the present time. If citizens are ever to fully appreciate and understand the technological society and its problems, a minimum background in the sciences is essential.

2. The "back-to-basics" movement is an established reality. What concerns many informed people is the narrow construction placed on the concept of "basic." The argument for science as "basic" as well as a component of general education should seem irrefutable in the contemporary world.[79]

3. Counseling of students appears to be either inadequate or ineffective or both. Sound counseling should help to establish long-range personal goals, provide adequate career orientation, ensure appropriate selection of courses and programs and help students to establish wholesome relationships with teachers and the schools. Counseling of girls and minorities not to take science and mathematics courses is particularly deplorable. Effective counseling should help to solve disciplinary, motivational and academic problems. It does not appear to have been notably successful in these areas.

4. The problem of student motivation is critical. The educational and social conditions which contribute to student apathy need to be identified and corrective measures taken. Efforts should be taken to determine if there is a physical basis for some of the problems: fatigue, inadequate diets, inadequate sleep, drugs, or other physical factors.

5. Discipline is an increasingly serious problem. Efforts need to be taken to reestablish the authority of the school and its agents. School personnel should be protected from frivolous legal actions. Harrassment and intimidation of teachers by students, parents and overly zealous bureaucrats must be stopped.

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[79]Howard J. Hausman, Choosing a Science Program for the Elementary School, Council for Basic Education, Washington, D.C., 1976.

6. There needs to be a reaffirmation of a concern for quality in education. The egalitarian philosophy reflected in many educational practices has had the unfortunate effect of encouraging regression toward mediocrity in many parts of the school curriculum. Efforts to reverse this regressive trend are starting. They should be encouraged and supported.

7. Professional education of teachers needs to be reexamined and high quality standards set for both undergraduate and graduate education and for accreditation and certification. Graduate study in any field requires reasonable blocks of time and periods of more or less continuous application. It requires excellent library resources and extensive use of such materials. Interactions over an extended period with peers deeply immersed in common problems has long been recognized as an exceedingly important aspect of graduate study. Appropriate courses in major supporting disciplines should be included.

8. The kind of education many people believe to be important is difficult to implement under present conditions in most schools. This includes laboratory activities on a systematic planned basis, other manipulative activities, lecture demonstrations, field work, and discovery, inquiry, or other inferential teaching modes. In the past science teachers did more of these things because they had more time and frequently did a considerable portion of their preparation after school hours and on Saturday mornings. New constraints now operate including union rules, busing schedules, more administrative duties, larger school districts with greater commuting time and distance for many teachers and other factors.

   A reasonable solution to the lack of teacher time is to provide paraprofessional assistants. Paraprofessionals can perform such duties as setting up and taking down laboratory and demonstration equipment, maintaining storerooms, checking inventories, ordering supplies, preparing reagents, making minor repairs, maintaining equipment, dispensing storeroom supplies to students, and maintaining aquaria, terraria, and animal cages.

   Under the National Defense Education Act millions of dollars were spent for laboratory equipment and facilities. Judging from the evidence in the three reports reviewed, a large part of this material is probably unused or inoperable. This is poor use of federal funds and is probably partially a reflection of inadequate technical assistance for teachers.

9. Efforts to improve the educational enterprise should utilize a team approach. The curriculum projects of the '60s tended to bypass important segments of the profession. All resources available should be tapped in large-scale efforts to improve curricula. When federal efforts in curriculum reform are initiated, most satisfactory results are likely to be obtained when state and local agencies, academicians, professional educators, and practitioners are involved. Total involvement should occur in the formative as well as in the productive and dissemination stages and it should be genuine participation at all levels including the establishment of policy.

10. Finally, and extremely important, efforts to improve the schools must start with consideration of the social environment. Unless the realities of the many pressures on the school administrators, teachers and students are understood, efforts to reform the curriculum or any other aspects of the educational establishment are likely to be abortive.

The ten action imperatives identified above are likely to remain empty statements unless solutions can be devised which will move from mere problem recognition to action programs. The three studies document convincingly that there are serious problems in American elementary and secondary education. Science, broadly defined to include the natural sciences, mathematics, and social studies, encompasess a major portion of the total secondary school curriculum and is heavily represented in the elementary school curriculum. It is also apparent that many of the implications for science so defined overlap into all of education. Thus, it may be impractical to try to extract science, broadly defined, from the larger matrix and treat it separately. In many cases, it is unrealistic to use the broad definition of science. The laboratory materials and maintenance problems are certainly of a different order in the natural sciences than in either mathematics or social sciences. There are certainly many other differences.

These complexities add greatly to the difficulty in identifying meaningful courses of action. The panel senses that we are at a critical turning point in American education. The confluence of important social, economic, and educational movements seems evident. The era of the great curriculum projects is passing into history and the goals and purposes of education seem once again to be called into question. It is within the context of these observations that the following recommendations are made.

Recommendations

Recommendation 1

Members of the panel agree that a commission of the highest quality with nationally recognized and respected leadership should be established to reexamine in depth the goals and purposes of American elementary and secondary education and to issue a major new statement to establish a framework for education and to provide a rationale and justification for new directions. It is the conviction of the panel that education in the sciences should be a major component of all three areas--general, college preparatory, and vocational--and that national attention needs to be directed to the serious problems in science as well as all of education.

The "Committee of Ten"[80] was able to redirect education through its efforts over 85 years ago and major statements on general education emanated from Harvard[81] and the Educational Policies Commission of the NEA[82,83,84] in various publications of over 30 years ago. But attention to general education and to the broad aims and purposes of education has tended to be subdued in recent decades. Study and a definitive statement of the relationship among general, college preparatory, and vocational education goals are urgently needed. The social and political context for education and the needs of the citizenry are now so sub-

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[80]National Education Association, Report of the Committee on Secondary School Studies, Committee on Secondary School Studies, U.S. Bureau of Education Bulletin No. 205, GPO, Washington, D.C., 1893.

[81]Harvard University, General Education in a Free Society, Committee on the Objectives of General Education in a Free Society, Harvard University, 1945.

[82-84]For citations, see page 35.

stantially changed that former statements are no longer suitable to the new circumstances.

The proposed commission should be free of bureaucratic and institutional constraints and provided with support staff and time to conduct their study. It would be desirable for the commission to be created by presidential appointment and preferably to be funded from nongovernmental agencies.

Recommendation 2

The panel recognizes that there are many more limited problem areas unsuited to detailed exploration and attention by a commission charged with broad and sweeping responsibilities for examining the educational establishment of the nation. Some areas will require persistent research efforts over time by highly qualified specialists or teams of specialists. The panel suggests the following as examples of areas which it perceives to be in need of major research efforts.

a) "The student" is seen as a rich source for investigation. The portrait of many students which emerges from the studies is not a very flattering one. Such terms as bored, apathetic, lazy, unmotivated, and uninterested are applied frequently to students. Research on motivation; counseling effectiveness; learning; impact of social factors including peer pressures, home life, community distractions and school activities; and attitude formation and change seems badly needed and its results need to be applied. Little is known about the impact of the curriculum on the individual student. This is an area where study is urgently needed. Continued support for such efforts is recommended.

b) Efforts are needed to protect students against the misassignment of teachers. This is a serious problem and one which is likely to grow worse because of the prevalence of reductions in staff in many school systems. At the very least, the general public, the state departments of education, and various accrediting and regulating bodies should be urged to give their attention to the problem and to do all they can to mitigate its effect. More reliable data on the extent of the problem is needed.

c) Inservice education of teachers continues to be a problem area. While there is general agreement that teacher renewal and updating is a necessity; the manner in which it is to be accomplished is far from settled. Mechanisms need to be devised to monitor the quality of inservice education. Graduate schools and accrediting agencies need to reaffirm their concerns for quality. Research

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[82]National Education Association, Education for All American Youth, A Further Look, Educational Policies Commission, National Education Association, 1952.

[83]National Education Association, The Purposes of Education in American Democracy, Educational Policies Commission, National Education Association, 1938.

[84]National Education Association, The Unique Function of Education in American Democracy, Educational Policies Commission, National Education Association, 1937.

is needed on all aspects of teacher inservice education programs but especially on the aspects relating to quality.

d) It is recommended that support be sought for programs and studies to determine what the contribution of paraprofessionals might be with special reference to increased teaching effectiveness and increased student learnings as indicated by their performance.

e) Extensive investigation of the function and role of values in the education of youth is recommended. This is an issue that should also be a concern of the commission (Recommendation 1).

Appendix A

PANEL TO REVIEW THREE NSF STUDIES

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